

CLAIMS

What Is Claimed Is:

5 1. A method for partially or completely removing organic coatings, films, layers or residues from a substrate, said method comprising:

(a) subjecting said organic coatings, films, layers, or residues to a precursor chemical or physical treatment;

10 (b) subjecting said organic coatings, films, layers, or residues to a vapor consisting essentially of water-free gaseous sulfur trioxide for a determinate period of time, said substrates being maintained at a temperature in the range from about room temperature to 400°C;

(c) subjecting said organic coatings, films, layers, or residues to a solvent rinse; and

15 (d) subjecting said organic coatings, films, layers, or residues to a chemical or physical post-rinse treatment.

20 2. The method of Claim 1 wherein said substrate is selected from the group consisting of semiconductor devices and wafers, ceramic devices, liquid crystal display devices, flat panel displays, printed circuit boards, magnetic read/write heads, thin-film read/write heads.

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3. The method of Claim 3 wherein said substrate is selected from the group consisting of Group IV elements, III-V compound semiconductors, oxides, nitrides, oxynitrides, organic films, organic dielectrics, organo-metallic complexes and polymers, metals, and metal alloys.

30 4. The method of Claim 3 wherein said Group IV elements are selected from the group consisting of silicon, polysilicon, and germanium, said III-V compound semiconductors consist essentially of gallium arsenide, said oxides are selected from the group consisting of crystalline and glassy oxides, and said organic dielectrics consist essentially of an organic polymer.

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5. The method of Claim 4, wherein said organic polymer is selected from the group consisting of polyimides, copolyimides, polyamides, polyamide-imides, fluorinated polyimides, poly(arylenethers), fluorinated poly(arylenethers), perfluorinated alkylene oxides, parylene (N, C, D, or F type), poly(phenylquin-oxalines), poly-naphthalene, poly-fluorinated naphthalene, benzocyclobutene (BCB), amorphous fluoropolymers, such as polytetrafluoroethylene, perfluorocyclobutane aromatic ether (PFCB), polynorbornene, and fluorinated carbon.

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10 6. The method of Claim 1 further including:

(a) treating said substrate to said precursor chemical or precursor physical treatment;

(b) placing said substrate in a chamber;

(c) purging said chamber with a dry inert gas;

15 (d) introducing said vapor consisting essentially of water-free gaseous sulfur trioxide into said chamber to react with said coating, film, layer, or residue;

(e) allowing an appropriate time to pass to permit reaction between said sulfur trioxide and said coating; and

20 (f) ending said reaction between said sulfur trioxide and said coating by subjecting said substrate to an end-point chemical or end-point physical treatment.

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25 7. The method of Claim 6 wherein said dry, inert gas consists essentially of nitrogen, or argon.

8. The method of Claim 1 wherein said precursor chemical treatment is selected from the group consisting of exposure to chemically active process gases, chemically inert process gases, and solvents.

30 9. The method of Claim 8 wherein said process gases are selected from the group consisting of oxygen, nitrous oxide, steam, vapor phase hydrogen peroxide, nitrogen, and argon.

Sub E7
5 10. The method of Claim 9 wherein said solvents are selected from the group consisting of water, lower alkanols, acetone, acids, bases, choline, amine-based solutions, and mixtures thereof.

Sub B4
10 11. The method of Claim 1 wherein said precursor physical treatment is selected from the group consisting of exposure to heat, electromagnetic radiation of suitable wavelength including ultra-violet light radiation (UV), laser energy, ultrasonic and megasonic sound energy.

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Sub E7
15 12. The method of Claim ³¹~~1~~ wherein said precursor chemical or physical treatment is carried out at a temperature between room temperature and 400°C.

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Sub E7
20 13. The method of Claim ³¹~~1~~ wherein said solvent rinse is performed in a solvent selected from the group consisting of water, lower alkanols, acetone, acids, bases, choline, amine-based solutions, and mixtures thereof.

20 14. The method of Claim 1 wherein said solvent rinse is simultaneously carried out in the presence of megasonic or ultrasonic energy, heat, electromagnetic radiation of suitable wavelength including ultra-violet light radiation (UV), or laser energy.

Sub A4
25 15. The method of Claim 1 wherein said post-rinse chemical treatment is selected from the group consisting of further exposure to chemically active process gases or vapors, chemically inert process gases, and solvents.

30 16. The method of Claim 15 wherein said process gases are selected from the group consisting of oxygen, nitrous oxide, steam, vapor phase hydrogen peroxide, nitrogen, and argon.

Sub E17
17. The method of Claim 15 wherein said solvents are selected from the group consisting of water, lower alkanols, acetone, acids, bases, choline, amine-based solutions, and mixtures thereof.

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Sub a5
18. The method of Claim 1 wherein said post-rinse physical treatment is selected from the group consisting of further exposure to heat, electromagnetic radiation of suitable wavelength including ultra-violet light radiation (UV), laser energy, kinetic energy, high-pressure deionized water sprays, physical scrubbing, CO₂ snow processing, ultrasonic and megasonic sound energy.

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Sub E17
19. The method of Claim ³~~4~~ wherein said post-rinse chemical or physical treatment is carried out at a temperature between room temperature and 400°C.

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Sub a6
20. The method of Claim 1 wherein step (b) further includes simultaneous exposure to chemical or physical treatment selected from the group consisting of other chemically active process gases and vapors, chemically inert process gases, vaporized solvents, heat, electromagnetic radiation of suitable wavelength including ultra-violet light radiation (UV), and laser energy.

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21. The method of Claim 20 wherein said process gases are selected from the group consisting of oxygen, nitrous oxide, steam, vapor phase hydrogen peroxide, nitrogen, and argon.

Sub E25
22. The method of Claim 20 wherein said solvents are selected from the group consisting of water, lower alkanols, acetone, acids, bases, choline, amine-based solutions, and mixtures thereof.

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23. The method of Claim ³~~4~~ wherein each said subjecting step is independently performed for a period of time up to about 5 minutes.

24. The method of Claim 1 wherein said organic coatings, films, layers and residues are selected from the group consisting of photosensitive and

non-photosensitive organic materials, polymerized photoresists, paints, resins, single and multilayer organic polymers, certain organo-metallic complexes, positive optical photoresist, negative optical photoresist, electron-beam photoresists, X-ray photoresists, ion-beam photoresists, ion-implanted photoresists, and other hardened photoresists.

25. The method of Claim ~~4~~³ further comprising: subjecting said organic coatings, films, layers or residues to a pre-rinse chemical or physical treatment subsequent to step (b).

26. The method of Claim 25 wherein said pre-rinse chemical treatment is selected from the group consisting of further exposure to chemically active process gases or vapors, chemically inert process gases, and solvents.

27. The method of Claim 26 wherein said process gases are selected from the group consisting of oxygen, nitrous oxide, steam, vapor phase hydrogen peroxide, nitrogen, and argon.

28. The method of Claim 26 wherein said solvents are selected from the group consisting of water, lower alkanols, acetone, acids, bases, choline, amine-based solutions, and mixtures thereof.

29. The method of Claim 25 wherein said pre-rinse physical treatment is selected from the group consisting of further exposure to heat, electromagnetic radiation of suitable wavelength including ultra-violet light radiation (UV), laser energy, kinetic energy, high-pressure deionized water sprays, physical scrubbing, CO₂ snow processing, ultrasonic and megasonic sound energy.

30. The method of Claim 25 wherein said pre-rinse chemical or physical treatment is carried out at a temperature between room temperature and 400°C.